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BLUE/DVD/CD COMPATIBLE OPTICAL HEAD WITH THREE WAVELENGTHS AND A WAVELENGTH SELECTIVE FILTER

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1. Introduction

Recently, rewritable optical disk systems using blue laser diodes, high NA objective lenses and thin cover layer disks have been developed[1][2]. Among them, a system using a single objective lens with a long working distance[2] is attractive because it features the possibility of the compatibility with DVD and CD. In order to realize the compatibility between disks with different substrate thicknesses, it is necessary to correct the spherical aberration for each disk. For this purpose, the authors have previously proposed two types of two-wavelength optical heads, which are a wavelength selective filter type[3] and a variable magnification type[4], and demonstrated the compatibility between DVD and CD. This paper further proposes a three-wavelength optical head combining a wavelength selective filter and variable magnification for blue rewritable optical disk, DVD and CD.

2. Optical Head Design

Figure 1 shows an optical head configuration. A 405nm light, a 650nm light and a 780nm light are used for the blue rewritable optical disk, DVD and CD, respectively. The blue rewritable optical disk has a 0.1mm-thick cover layer. Two interference filters multiplex and demultiplex light beams of three wavelengths. An objective lens is designed for the 405nm light and the 0.1mm-thick cover layer with a magnification of zero. The NA for the 405nm light is 0.7. There is a wavelength selective filter in front of the objective lens. The magnifications of the objective lens for the 650nm light and the 780nm light are designed to be 0.076 and 0.096, respectively, so as to minimize the spherical aberrations. The NAs for the 650nm light and the 780nm light are restricted to be 0.6 and 0.45, respectively, by apertures in the corresponding optics.

Figure 2 shows a wavelength selective filter structure. It consists of a concentric phase filter pattern. The phase filter pattern has a four-level staircase-shaped cross-sectional structure. The phase difference between transmitted lights through adjacent levels is given by $\phi=2\pi(n-1)h/\lambda$, where n is a refractive index of the phase filter pattern, h is a difference of height between adjacent steps, and λ is a wavelength of the incident light. ϕ is designed to be 2π for the 405nm light, so as not to affect the phase distribution of the transmitted light. In this case, ϕ becomes 1.25π for the 650nm light and 1.04π for the 780nm light, and the phase distribution of the transmitted light is varied according to the pattern.

The phase filter pattern is designed so as to minimize the residual spherical aberration for the 650nm light. Table 1 shows a result of the phase filter pattern design. The left column represents a height of the incident light upon the objective lens (r) normalized by a focal length of the objective lens (f), while the right column represents a corresponding number of levels of the phase filter pattern.

Figures 3(a) and 3(b) show calculated wavefront aberration characteristics for the 650nm light and the 780nm light, respectively. The vertical axis represents r/f, while the horizontal axis represents the wavefront aberration. The gray line and the black line correspond to the results without and with the wavelength selective filter, respectively. The RMS wavefront aberrations for the 650nm light and the 780nm light with the wavelength selective filter are reduced to be 0.047λ and 0.021λ, respectively, both of which satisfy the Marechal's criterion.

3. Experimental Results

Figures 4(a) and 4(b) show readout signal waveforms for a DVD and a CD, respectively. A data-to-clock jitter for the DVD and a data-to-data jitter of 3T signals for the CD were 7.6% and 8.4% of the detection windows, respectively, both of which are low enough for practical use. Moreover, an influence of the wavelength selective filter on a readout signal for the blue rewritable optical disk was hardly observed. From these results, the validity of this optical head design has been confirmed.

References
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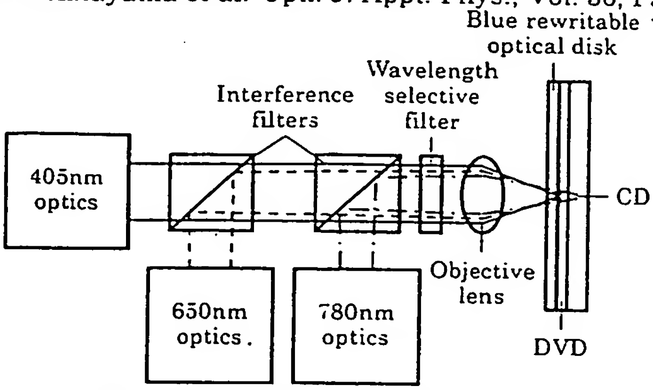


Fig. 1 Optical head configuration.

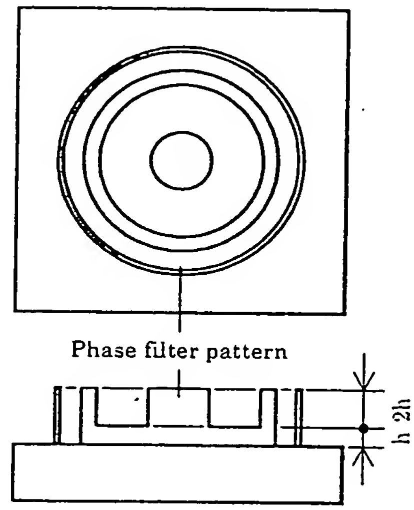
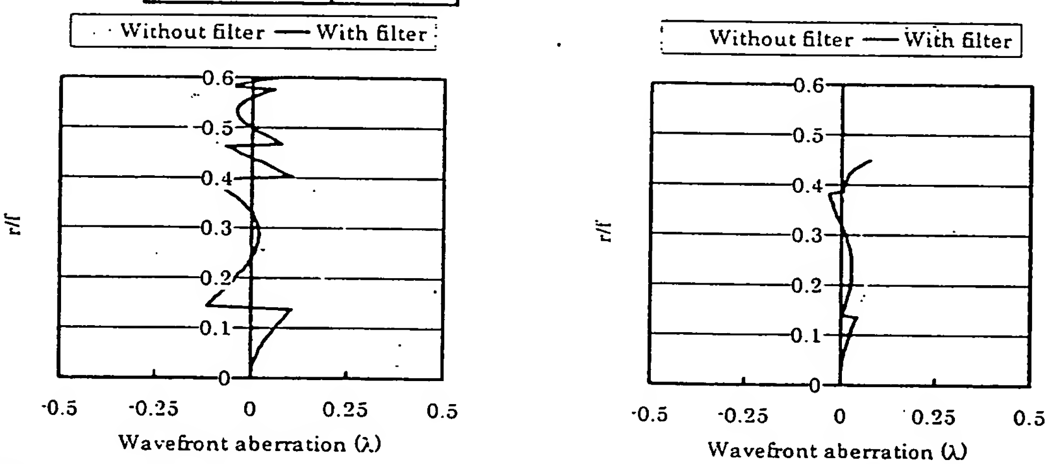


Fig. 2 Wavelength selective filter structure.

Table 1 Phase filter pattern design.

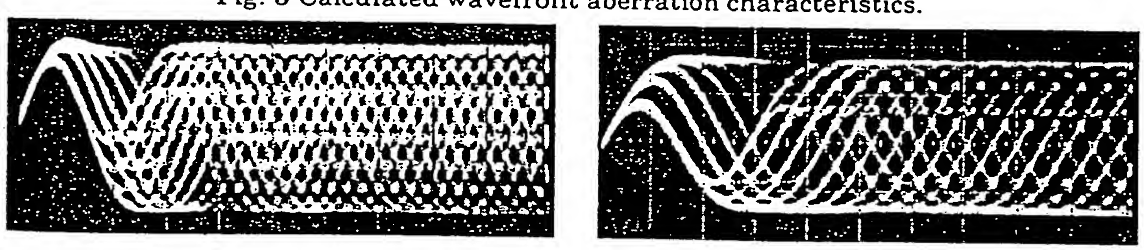
r/f	Level
0.000~0.145	3
0.145~0.401	1
0.401~0.472	3
0.472~0.577	0
0.577~0.600	3



(a) 650nm light

(b) 780nm light

Fig. 3 Calculated wavefront aberration characteristics.



(a) DVD

(b) CD

Fig. 4 Readout signal waveforms.